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(54) AMMUNITION, AND A METHOD AND ARRANGEMENT FOR CONTROLLING THE FIRING OF SUCH AMMUNITION FROM A WEAPON

(71) We, RHEINMETALL GMBH, a German Body Corporate, of 4 Dusseldorf, Postfach 6609, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:

The present invention relates to ammunition, and a method and an arrangement for controlling the firing from a weapon of such ammunition.

In order to increase the accuracy of the fire of weapons it is already known to take into consideration external ballistic data which affect a projectile, such as for example cross winds at the time of firing. It has been found that this data is still not sufficient to ensure an accurate striking of the target with the first shot. In order not to be destroyed oneself, the accuracy of the first shot is of the greatest importance, since misfiring or trying out the range of a weapon reveals one's position to the enemy.

In addition, it is already known to set the fuses of ammunition located in the barrel of a weapon by inductive potential, a wire being wound around the barrel adjacent a coil connected to the fuse. By a brief application of voltage corresponding to the distance of the target, the fuse is set.

Since the muzzle velocity and therefore the trajectory of a projectile depends on the powder temperature, attempts have been made to measure the powder temperature in order that it can also be taken into consideration when positioning the weapon. For this purpose, several concentric mutually insulated rings have been provided in the base of the ammunition casing to which is connected an electric temperature measuring element located in the powder of the projectile cartridge. The powder temperature can thus be ascertained.

It is an object of the present invention to improve the accuracy obtainable when firing a weapon. According to the present invention, there is provided a method of controlling the firing from a weapon of ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent, and an ammunition identifying circuit, each circuit being connected to a common terminal wherein data about the target is supplied to a fire control computer, successive characteristically different electric signals are supplied via a single common lead to the common terminal of ammunition located within the weapon barrel by means of devices connected to the fire control computer, successive signals energising the fuse activating circuit and the measuring and indicating circuits respectively, signals representative of the temperature and identity of the ammunition are derived from the measuring and identifying circuits and applied to the fire control computer, and the derived signals are processed with the data about the target in the fire control computer to provide control signals to weapon control circuits which position the weapon and/or set the ammunition fuse.

According to the present invention, there is also provided an arrangement for controlling the firing from a weapon of ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent and an ammunition identifying circuit, each circuit being connected to a common terminal, the arrangement comprising a fire control computer, devices connected to the fire control computer for generating succes-

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sive characteristically different signals and supplying the generated signals via a common lead to ammunition located within the weapon barrel, the successive signals being arranged to energise the fuse activating circuit and the measuring and identifying circuits respectively, the fire control computer being arranged to receive signals derived from the measuring and identifying circuits of the ammunition and to receive input data about the target, to process the received signals and data, and to provide control/signals to weapon control circuits adapted to position the weapon and/or set the ammunition fuse.

According to the present invention, there is also provided ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent, and an ammunition identifying circuit, each circuit being connected to a common terminal.

The type of ammunition, for example explosive incendiary projectiles, hard core or hollow charge projectiles with time fuses, impact detonators or proximity fuses, can have different muzzle velocities which should be taken into account if accuracy is to be maintained. The present invention enables the accurate firing of a variety of types of ammunition.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 shows diagrammatically a projectile cartridge connected to a firing control computer, the cartridge being located in a barrel of a weapon;

Fig. 2 is a diagrammatic circuit diagram of an activating device;

Fig. 3 is a graph showing the sequence of the measuring and control signals when using a series of pulses for setting the fuse;

Fig. 4 is a graph showing the current flow curves for various types of projectile when using different capacitors as elements for recognising the type of ammunition;

Fig. 5 is a graph showing the sequence of the measuring and control signals when using negative voltage pulses for setting the fuse and,

Fig. 6 is a graph showing current flow curves for various types of projectile when using different resistors as elements for recognizing the type of ammunition.

A projectile cartridge with a case 2*a* and a projectile 2*b* is located in a cartridge chamber 1*a* of a barrel 1 of a piece of ordnance (Fig. 1). The projectile cartridge is secured in the barrel 1 of the piece by a breech-block mechanism 3. A threaded electrical primer 4, is screwed into the case 2*a*. A central contact 6 constructed as an electrical pole and insulated by a layer of synthetic material is located in the primer 4. The central contact 6 is connected by a diode 7 to a temperature sensing element 9, for example in the form of a thermistor, and to an element characterising the type of ammunition in the form of a capacitor 8*a*. The element 9 and capacitor 8*a* are connected in parallel between the central contact 6 and the body of the threaded primer 4. There is connected in parallel to this circuit a four-layer diode 11 in series with an electrical propellent charge igniter 12 which is surrounded by propellent charge powder 10. The central contact 6 is connected by plug and socket connections 14 to a projectile fuse 15, which can be a delay fuse or time fuse, a proximity fuse or an impact detonator. There is located in the fuse 15 a fuse activating device 39, which receives a signal *via* a signal discriminating device 13, and which makes the ammunition live only after the ammunition has been inserted in the cartridge chamber 1*a* of the barrell of the piece. In the example illustrated the device 13 comprises a diode 13*a* and an electronic time fuse is provided which is set by a fire control computer, as will be described hereafter, and for this purpose a counting chain 36, with a storage device 38 connected on the load side, and a pulse generator 35 preferably in the form of a quartz crystal timer are provided. The counting chain 36 is connected to the central contact 6 by a diode 33 and the plug and socket contacts 14 and is controlled by the pulse generator 35 such that a signal is sent to an ignition element 37 when a specified time for firing the projectile has been reached.

It will be seen that each of the diodes 7, 11, 13*a* and 33 are connected to a common terminal, the polarity of the diode 13*a* relative to that terminal being opposite to the polarities of the diodes 7, 11 and 33.

It should be noted that in a projectile with, for example, an impact detonator, the activating device 39 can consist of a simple switch member, which makes the fuse live. It can however also consist of a power storing device, to which the necessary power is supplied from outside by a power supply device. Finally it can be an active power source, which is switched on from outside, or a combination of both.

The activating device 39 serves for supplying power to both the pulse generator 35 as well as the counting chain 36 and the storage device 38. In addition, it serves for supplying ignition current to the ignition device 37.

A preferred embodiment of the activating device 39 is divided into a first voltage

supply means 39*a* for supplying ignition current to the ignition member 37 and a second voltage supply means 39*b* for supplying low voltage power to the pulse generator 35, the counting chain 36 and the storage device 38. As shown in Fig. 2, the low voltage part 39*b* may comprise a capacitor 41 connected in parallel with a Zener diode 42. The capacitor 41 is arranged to be charged *via* a resistor 43 and a rectifier 13*b* to a voltage of for example, about 15V, illustrated by the first part of the signal *c* (Fig. 3). The ignition voltage part 39*a*, consisting of a capacitor 40, is then charged by the rectifier 13*a* to a voltage of approximately 100V, illustrated by the second part of the signal *c*. Since the Zener diode 42 becomes conductive at a voltage above 15V, the voltage across the capacitor 41 is independent of the higher ignition voltage and remains at its former value.

In a further development of this embodiment, a power source is provided in the form of an electrical battery 44 connected in parallel with the low voltage capacitor 41. This battery 44 supplies power to the pulse generator 35, the counting chain 36 and the storage device 38, after the projectile 2*b* has left the barrel 1 of the piece. For this purpose an acceleration responsive switch 34 is interposed, which only makes a connection when the acceleration phase has ended. This avoids it being necessary for the battery 44 to be constantly connected to the pulse generator, the counting chain 36 and the storage device 38 and to thereby discharge itself.

It should be noted that the ignition voltage does not of necessity have to be supplied from outside. It can also be produced by means of induction by the low voltage part 39*b*. Thus it is possible to avoid providing a source of ignition voltage on the piece, although this makes the fuse more complicated. During the high acceleration after the ignition of the propellent charge, the pulse generator 35 may not work correctly. However, as the pulse generator 35 is connected to the counting chain 36 by the acceleration-responsive switch 34 only after the acceleration phase, this does not cause problems.

The central contact 6 is connected to a change-over switch 20 by a contact 17 insulated in a layer of synthetic material 16. This change-over switch has on the one hand an input II for receiving an ammunition activating signal, which is produced in a device 45 and which, as already mentioned, may comprise either a pulse signal, which switches on the activating device 39, or a voltage signal of a certain duration, which charges the activating device 39. Another input I of the change-over switch 20 is connected to a fire control computer 18 by a device 27 for identifying the type of ammunition and a temperature measuring device 28. The fire control computer 18 activates mechanism 22 for positioning the weapon and for setting the fuse 15 depending on the data supplied, i.e. target correction data, which is provided by an element 26, the original target data which is provided by an element 25, the type of ammunition, which is indicated by the element 27, and the powder temperature, which is indicated by the element 28. The data supplied is applied to a pulse transmitter 32 which provides a series of pulses the number of which is representative of the data supplied. These pulses are preferably sent to the ammunition *via* an AND gate 31 and the change-over switch 20. The second input of the gate 31 is connected to a firing button 21, so that the pulses from the pulse transmitter 32 are only passed on to fuse 15 after the firing button 21 has been pressed.

According to a further embodiment (not shown) the setting of the fuse 15 is controlled by negative voltage pulses *d'* (Fig. 5), the voltage level of which are determined by the data supplied. The different voltage level of the illustrated voltage pulses reproduce the values of the data which are continuously altering up to the moment of firing.

The first pulse coming from the gate 31 is further sent *via* a delay device 30 to the propellent charge ignition device 29, which passes on a signal *e* (Figs. 3 and 5) in the form of a greatly increased voltage to the electric propellent charge igniter 12, the ignition voltage being measured such that the four-layer diode 11 only becomes conductive at this voltage. Naturally, the four-layer diode 11 can be replaced by another equivalent device, which has a blocking action in one direction and becomes conductive at a certain voltage.

It should be noted that the electrical delay device 30 is only necessary if the time between the actuation of the electric propellent charge igniter 12 and the ignition of the propellent charge is too short for sending the fuse setting pulses to the fuse.

The method of operation of the arrangement according to the invention is as follows: After placing the ammunition in the ammunition chamber of the piece and switching on the firing control computer, the change-over switch 20 alternately establishes a connection between one of its inputs I and II and its output III, beginning with a connection between the input I and and the output III. At this moment a steady predetermined voltage is applied to the capacitor 8*a* and the resistor 9 across the diode 7. This voltage corresponds to the

signal *a* in Fig. 3. The capacitance of the capacitor 8*a* is chosen according to the type of ammunition, so that the charging current shown in Fig. 4 result. Inside the ammunition identifying member 27 there is provided a current measuring device 27*b* and a delay member 27*a* arranged so that the charging current is measured a certain time T after switching on the voltage. According to the type of ammunition, a current I_1, I_2, or I_3 is measured (Fig. 4), and supplied to the firing control computer 18, which uses the current measurement for setting the fuse 15. After the charging current through the capacitor 8*a* dies away, there flows through the thermistor 9 only the constant current I_4, induced by the steady voltage corresponding to the signal *b* in Fig. 3, the value value of the current I_4 depending on the instantaneous resistance of the thermistor 9. The temperature measuring member 28 measures this current and provides a signal which is indicative of the temperature of the propellent charge to the firing control computer 18. The voltage applied to the temperature measuring circuit and the ammunition identifying circuit via the central contact 6 has positive polarity whereas the signal *c*, which is produced by the device 45, has a negative polarity. This signal *c* reaches the activatiing device 39 when the change-over switch 20 produces the connection between the input II and the output III. After a certain time the change-over switch 20 switches back to the connection between the input I and the output III, the steady voltage is again supplied to the contact 6. The contact 6 thus receives successive signals of opposite polarity. After another switching to the connection between the input II and the output III a connection is again made between the device 45 and the activating device 39. It should be noted that the alternating input of positive and negative signals *a, b, c* can be used to return the counting chain to a definite starting position, so that these signals do not influence the setting of the fuse.

By pressing the firing button 21 at the point A (Fig. 3) the change-over switch 20 is instantaneously switched back to the connection between the input I and the output III. A signal is sent to the gate 31, which thus sends the pulses *d* (Fig. 3), which come from the pulse transmitter 32, to the counting chain 36 by way of the change-over switch 20, the plug and socket connections 14 and the diode 33. With a certain delay, which is determined by the delay device 30 or by the ignition delay of the propellent charge, the greatly increased voltage signal *e* is produced by the propellent charge ignition device 29 and reaches the electric propellent charge igniter 12 through the four-layer diode 11 which is conductive at this voltage. Thus, the ignition of the propellent charge occurs and the projectile is accelerated in the barrel of the piece. During the acceleration phase the acceleration-responsive switch 34 is opened, so that the pulse generator 35 is separated from the counting chain 36. After the projectile leaves the barrel, the acceleration ceases and the pulse generator 35 is connected to the counting chain 36. From this point on the pulse generator 35, the couunting chain 36 and the storage device act upon each other such that after a period corresponding to the number of pulses supplied, a signal is sent to the ignition device 37, which explodes the projectile.

The afore-described method relates to a projectile with a time fuse. If it is a question of a projectile with a proximity fuse, the signal coming from the pulse counter 36 does not cause the projectile to explode, but activates the proximity fuse a short distance from the target, so that a premature explosion by the response of the proximity fuse to objects other than the target is avoided.

It should be noted that the member 8*a* for identifying the type of ammunition does not necessarily have to be a capacitor, as shown, but can be replaced by other electrical members, such as, for example, a resistor or an inductance or a combination of the three said members. When using resistors of different resistances for identifying the different types of ammunition, and assuming that the powder temperature alters with the time T, according to the type of ammunition, there result, for example, the current flow curves I_1, I_2, I_3 illustrated in Fig. 6.

Under certain circumstances, the gate 31 can be dispensed with, so that the pulses, which come from the pulse transmitter 32, are sent to the fuse 15 from the end of the activating signal *c*. In this case, the setting of the fuse would alter continuously until the moment of firing. Care is taken that the last pulse sequence before firing effects the final setting of the fuse.

WHAT WE CLAIM IS:—

1. A method of controlling the firing from a weapon of ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent, and an ammunition identifying circuit, each circuit being connected to a common terminal wherein data about the target is supplied to a fire control computer, successive characteristically different electric signals are supplied *via* a single common lead to the common terminal of ammunition located within the weapon

barrel by means of devices connected to the fire control computer successive signals energising the fuse activating circuit and the measuring and identifying circuits respectively, signals representative of the temperature and identity of the ammunition are derived from the measuring and identifying circuits and applied to the fire control computer, and the derived signals are processed with the data about the target in the fire control computer to provide control signals to weapon control circuits which position the weapon and/or set the ammunition fuse.

2. A method according to claim 1, wherein all the signals are applied to the ammunition *via* a single insulated central contact engaged with the ammunition.

3. A method according to claim 1 or 2, wherein the electrical signals comprise successive signals of opposite polarity.

4. A method according to claim 1, 2 or 3, wherein a series of pulses are applied by the weapon control circuits to the ammunition to set the ammunition fuse, the number of pulses being determined by the control computer in dependence upon the derived signals and the target data.

5. A method according to claim 1, 2 or 3, wherein a series of pulses are applied by the weapon control circuits to the ammunition to set the ammunition fuse, the levels of the voltage pulses being determined by the control computer in dependence upon the derived signals and the target data.

6. An arrangement for controlling the firing from a weapon of ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent and an ammunition identifying circuit, each circuit being connected to a common terminal, the arrangement comprising a fire control computer, devices connected to the fire control computer for generating successive characteristically different signals and supplying the generated signals via a common lead to ammunition located within the weapon barrel, the successive signals being arranged to energise the fuse activating circuit and the measuring and identifying circuits respectively, the fire control computer being arranged to receive signals derived from the measuring and identifying circuits of the ammunition and to receive input data about the target, to process the received signals and data, and to provide control signals to weapon control circuits adapted to position the weapon and/or set the ammunition fuse.

7. An arrangement according to claim 6, comprising a pulse transmitter connected to the control computer and arranged to apply ammunition fuse-setting pulses to the common lead, the number of the fuse setting pulses being determined by the fire control computer in dependence upon the said derived signals and target data.

8. An arrangement according to claim 6 or 7, wherein switching elements are provided which are responsive to the derived signals indicative of ammunition identity to provide control signals dependent upon the type of ammunition identified.

9. An arrangement according to claim 6, 7 or 8 comprising a pulse transmitter connected to the common lead via one input of a two input AND gate, the other input of the gate being connected to a firing button so that the output of the pulse transmitter reaches the common lead only after the firing button is activated.

10. Ammunition comprising a cartridge casing, a projectile, a propellent, a firing circuit arranged to detonate the propellent, an ammunition fuse, a fuse activating circuit, a temperature measuring circuit arranged to indicate the temperature of the propellent, and an ammunition identifying circuit, each circuit being connected to a common terminal.

11. Ammunition according to claim 10, comprising a single insulated control contact arranged to connect with the fuse activating circuit, the temperature measuring circuit, and the ammunition identifying circuit via the said common terminal.

12. Ammunition according to claim 11, wherein the single insulated central contact is supported by an electrical primer in screw-threaded engagement with the casing.

13. Ammunition according to claim 10, 11 or 12, wherin the firing circuit comprises an electric propellent igniter connected to the common terminal by a four-layer diode, the temperature measuring circuit comprises a temperature-responsive resistor, the ammunition identifying circuit comprises an electrical device the characteristics of which identify the ammunition, and the fuse activating circuit comprises a switching circuit, the temperature measuring and ammunition identifying circuits being connected to the common terminal by a rectifier having the same polarity as the four layer diode, and the switching circuit being connected to the common terminal by a rectifier the polarity of which is opposite to the polarity of the four layer diode.

14. Ammunition according to claim 13, comprising a further switching circuit for setting the ammunition fuse, the said further switching circuit being connected to the common terminal by a rectifier having the same polarity as the four layer diode.

15. Ammunition according to claim 14, wherein the switching circuits comprise a

counting chain the load side of which is connected to a storage element, a pulse generator and an acceleration responsive switch, the acceleration responsive switch being arranged to connect the pulse generator to the counting chain after acceleration, and the counting chain and storage element being arranged to activate a projectile ignition device after the counting chain has received a number of pulses from the pulse generator, the said number depending upon the contents of the storage element.

16. Ammunition according to claim 15, comprising first voltage supply means for supplying an ignition voltage to the ignition device and second voltage supply means for supplying a lower voltage to the switching circuits.

17. Ammunition according to claim 16, wherein the first voltage supply means comprises a capacitor connected in series with a rectifier and the second voltage supply means comprises a capacitor connected in parallel with a zener diode and in series with a resistor and a further rectifier.

18. Ammunition according to claim 16 or 17, comprising an active power source arranged to be connected by an acceleration-responsive switch in parallel with the second voltage supply means, the acceleration responsive switch enabling the active power source to supply power only after the ammunition has been fired.

19. A method of controlling the firing of a weapon substantially as herein described with reference to the accompanying drawings.

20. An arrangement for controlling the firing of a weapon substantially as herein described with reference to the accompanying drawings.

21. Ammunition substantially as herein described with reference to the accompanying drawings.

MARKS & CLERK,
Agents for the Applicants.

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1377398 COMPLETE SPECIFICATION
5 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

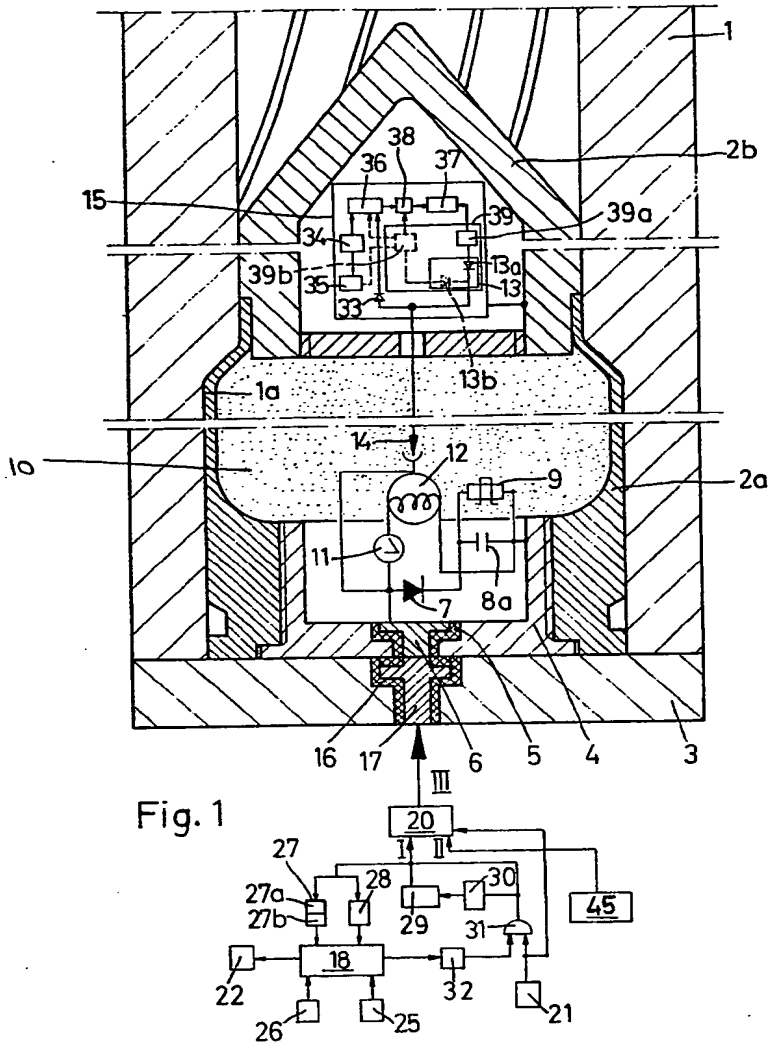

Fig. 1

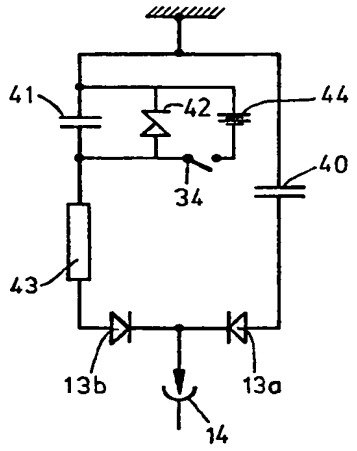

Fig.2

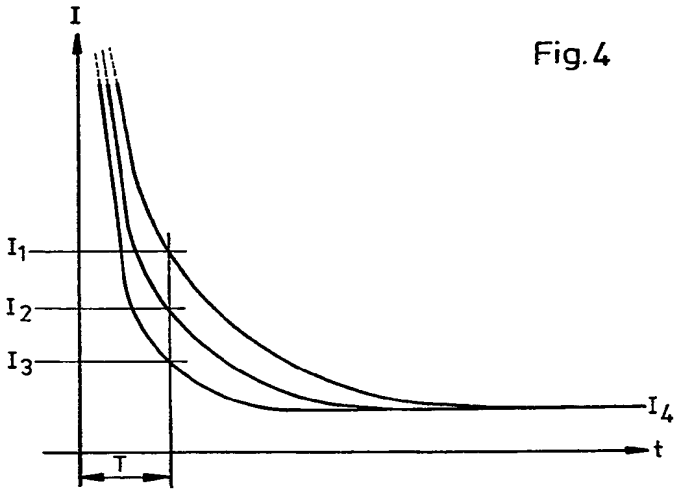

Fig.4

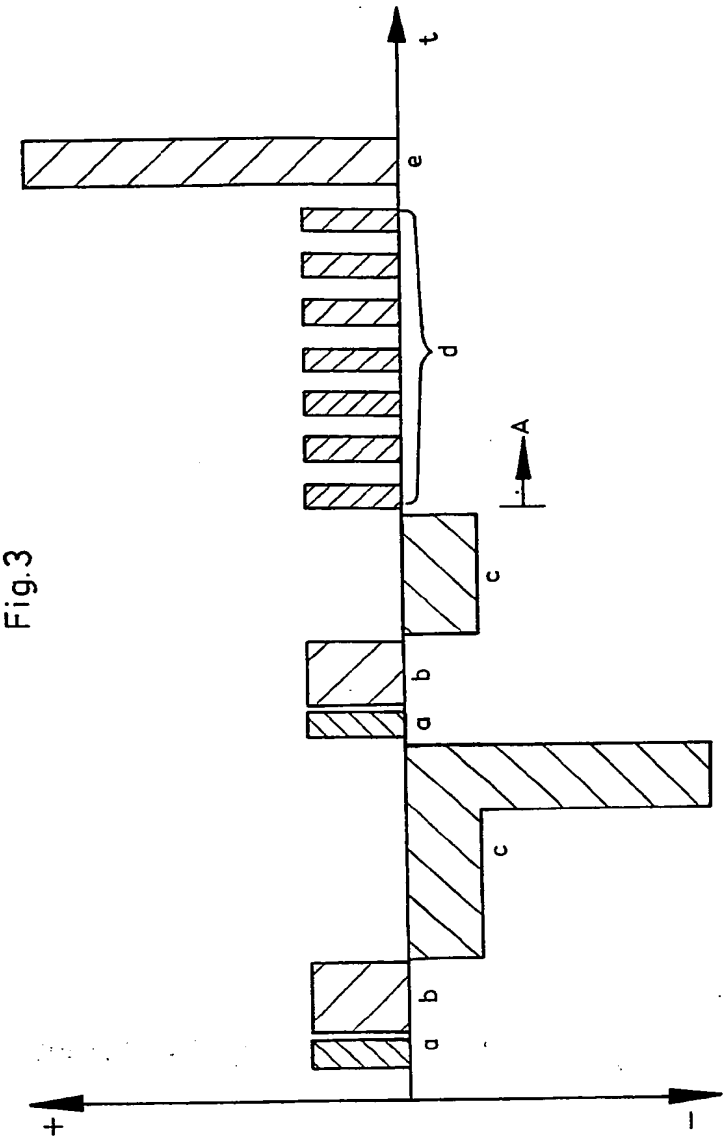

Fig.3

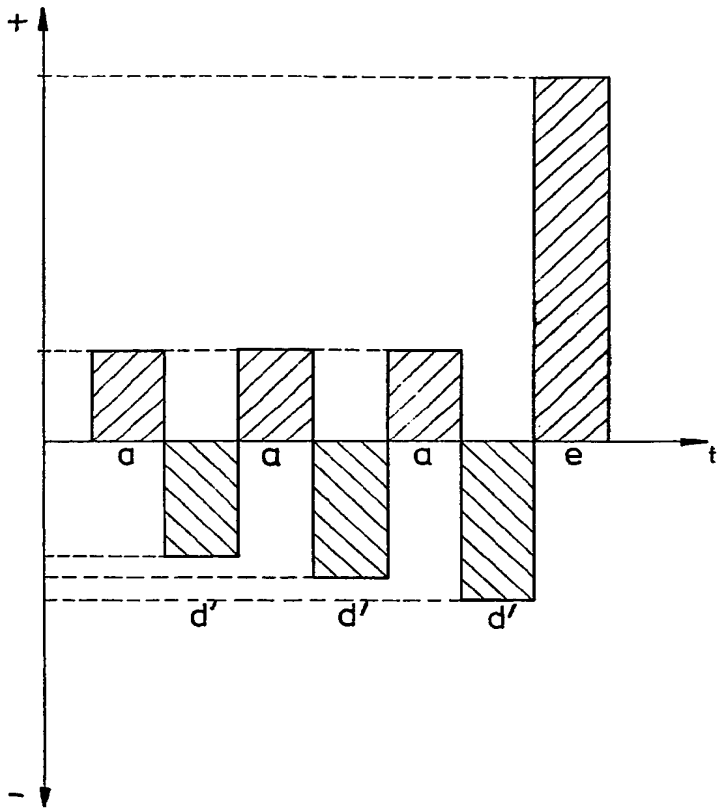

Fig.5

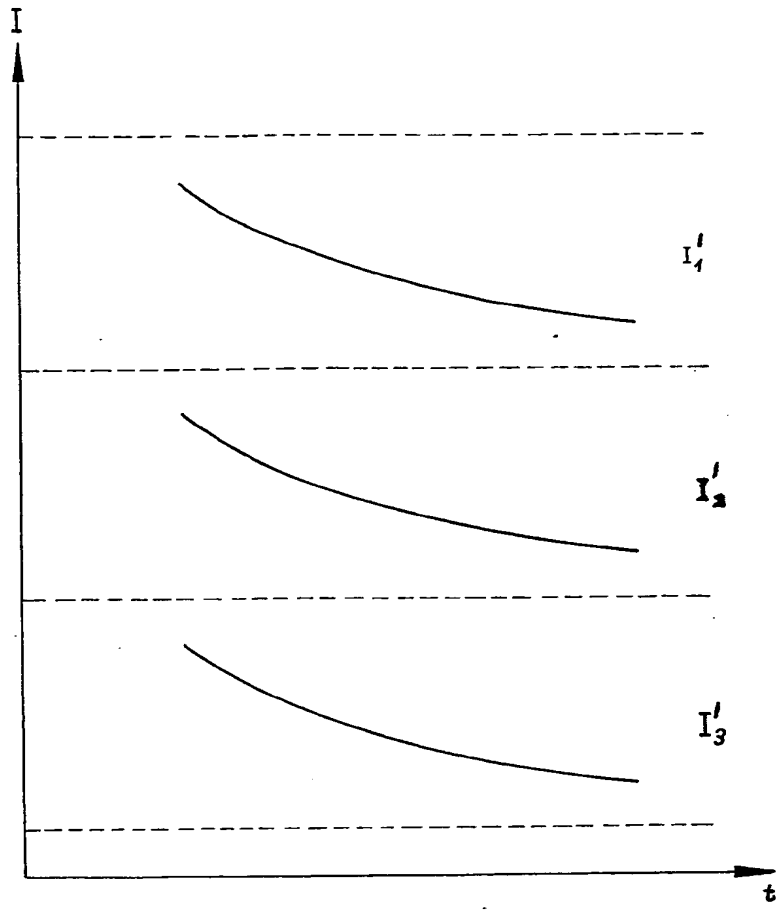

Fig.6